ADDITIONS TO THE FLORA OF CRATER MT., PAPUA NEW GUINEA

W. Takeuchi

Botanical Research Institute of Texas (BRIT)
c/o Lae National Herbarium and Papua New Guinea Forest Research Institute
P.O. Box 314, Lae, Morobe Province 411, PAPUA NEW GUINEA

ABSTRACT

The floristic checklist for the Crater Mt. Wildlife Management Area (CMWMA) is updated. *Canarium acutifolium* var. *pioriverensis* (Burseraceae) is newly described.

KEY WORDS: Botanical survey, *Canarium*, Papuasia

ABSTRACT (JAPANESE)

クレイター山 野生生物 管理地区の植物チェックリストを最新のものに改める。
Canarium acutifolium var. pioriverensis **(ブルセラ科) は新たに記述されている.**

INTRODUCTION

As one of Papuasia's largest wilderness environments, the Crater Mt. Wildlife Management Area (CMWMA) was recently a focal venue for an intensive program of floristic exploration and documentation. In the following account, an earlier botanical summary of the CMWMA (cf. Takeuchi 1999) is updated with several additions and corrections.

BURSERACEAE

Canarium acutifolium (DC.) Merr. var. **pioriverensis** Takeuchi, var. nov. TYPE: PAPUA NEW GUINEA. CHIMBU PROVINCE: Crater Mt. Wildlife Management Area, Pio River, alluvial forest, 06°47'S, 145°02'E, 500 m, 25 Mar 1997 (stam. fl.), *W. Takeuchi 11,886A* (HOLOTYPE: LAE; ISOTYPES: A, BRIT, L).

Differt a *C. acutifolio* (DC.) Merr. var. *aemulans* folioliis longioribus usque ad 43 cm longis, stipulibus majoribus usque ad 25 × 6 mm, fructibus ellipsoideis 24–27 × 12–14 mm.

Canopy tree, 25–30 m tall, deciduous, plank-buttressed to ca. 1 m height, outer bark furrowed, pallescent, slash ferruginous to ochraceous, clear-resiniferous, wood white, very dense. *Branchlets* longitudinally corrugate, ca. 1.5 cm diam., minutely furfuraceous, pithy, not hollowed with age; vascular strands peripheral, appressed to the pith. *Leaves* spiral, phyllotaxy 2/4, 6–8 jugate, 1.0–1.4 m long, the flush emerging simultaneously with flowering; leaflets membranaceous, (ovate), elliptic-oblong, or oblong, decrescent on the rachis, (11–)20–31(–43) × (6.5–)9.0–14.0 cm, apex rounded or (obtusely acuminate), base truncate to (cuneate), margins entire; venation camptodromous, bifacially prominulous, secondaries 10–15(–16), at the leaflet center diverging 55–70° from costulae, gradually arcuate or turning abruptly at the margin, crossing nerves scalariform, reticulum dense; laminar surfaces adaxially dark dull green, abaxially medium green, on both sides pusticulate, all parts with an indument of appressed furfuraceous hairs; petiolule terete

or compressed, pulviniform at both ends, 9–25 × 1.5–2.5 mm; rachis cylindrical, shallowly sulcate, purple-green; petiole 250–390 × 7–10 mm, dilate at the branchlet, articulative or not, broadly concave on the upper side, rounded beneath; stipules persistent, inserted at the base of the petiole, acuminate, 14–16(–25) × 3–4(–6) mm, flat, paired, evenly tapered to the apex. *Staminate inflorescence* axillary (lateral), thyrsoid, pyramidal, 51–60 cm long, rachide branches to 15 cm long, all axes glossy green or reddish-green and with an indument of pale scalelike hairs; rachis bracts narrowly acuminate, the larger ones 7–10 mm long, higher order bracts ovate, 1–2 mm long, undulate; peduncle 170–240 × 4–5 mm. *Staminate flowers* ellipsoid-oblongoid in bud, perianth 3-merous; calyx tubiform, ca. 5 × 3 mm, 1/2–2/3 connate, lobes ovate, densely sericeous on inner surfaces, glabrate or puberulent outside; corolla distinct, imbricate, petals lanceolate-oblong, 6–7 mm long, adaxially glabrous, externally with lax sericeous hairs; stamens 6, uniseriate, equal, united at the base into a glabrous column ca. 1 mm high, filaments plane, 0.5–0.75 mm long, anthers basifixed, sagittate, mucronulate, oblongish, ca. 2.5 × 0.5 mm, erect, pilosulous; disk dome-shaped or globular, rugose, glabrous, ca. 1 mm high and not exceeding the column, 6-lobulate, recessed at the summit; pistillode absent. *Pistillate inflorescence* unknown. *Infructescence* axillary (lateral), occasionally from defoliate nodes, ebracteate, puberulous, ca. 20 cm long, branching only at the top, peduncle 170 × 4 mm. *Drupe* ellipsoid or (subovoid), 24–27 × 12–14 mm, obtusely 6-angled in cross-section, apex acute or bluntly rostrate, locules 3, 2 of the cells sterile and rudimentary, exocarp with scattered subappressed hairs; calyx persisting, spreading, not accrescent, lobes deltate or rounded, 3.0 × 3.5 mm, adaxially densely sericeous, externally glabrate.

Distribution and habitat.—Known thus far only from lowland forest in the CMWMA.

Etymology.—The varietal name commemorates the type locality.

PARATYPE: PAPUA NEW GUINEA. CHIMBU PROVINCE: Crater Mt. Wildlife Management Area, Pio River, foothill forest, 06°47' S, 145°02' E, 500 m, Jan 1998 (fr.), *W. Takeuchi 11,886B* (LAE).

Malesian *Canarium* has been treated by Leenhouts (1955a, 1955b, 1956, 1959; cf. also Steenis 1972). There are 20 species reported from New Guinea (ibid).

The new taxon belongs to section *Pimela* (Lour.) DC. and is related to the complex consisting of *C. acutifolium* (DC.) Merr. and its allies. Because of the 6-staminate flowers, the novelty is comparable to *C. acutifolium* var. *aemulans* but is more robust, with leaflets to 43 × 14 cm and with larger stipules to 25 × 6 mm. Although var. *acutifolium* has similar panicles, the fruits of var. *pioriverensis* are 24–27 mm long (up to 15.0–17.5 mm for the other varieties of *A. acutifolium*). The deciduous phenology of var. *pioriverensis* is also distinctive. According to village respondents the new tree is characteristically leafless immediately prior to flowering. Their report is substantiated by the fact that other individuals of the same variety were seen in leafless condition near the type collection and later exhibited synchronous flowering and leaf flush. The correspondence between leaf and flower emergence is clearly reflected on the type, which has denigricant membranaceous leaves unlike the coriaceous blades usually seen on herbarium sheets of congeners.

The new variety will key to the species using the modified sequence in Steenis (1972) and can be incorporated into the varietal conspectus by replacing lead 2b (Leenhouts 1956: 292) with the following continuation.

2. Nerves 12–15 pairs
Leaves 2–4-jugate, leaflets 7–18 × 3.5–8.5 cm, abruptly acuminate; stipules subulate, to 17 × 1.5 mm; fruits subglobose, to 17.5 × 15 mm _____ var. **aemulans**
Leaves 6–8-jugate, leaflets (11–)20–31(–43) × (6.5–)9.0–14.0 cm, apex obtuse or (gradually subacuminate), never abruptly developed; stipules acuminate, flat, broader, to 25 × 6 mm; fruits ellipsoid, 24–27 × 12–14 mm _____ var. **pioriverensis**

OTHER COLLECTIONS

ADIANTACEAE

Coniogramme macrophylla (Bl.) Hieron.; coll. *12,197*. Initially reported as 'sp. nov. aff. *macrophylla*' (Takeuchi 1999: 953), the CMWMA plants have once-pinnate fronds with pinnae to 36 × 5 cm. Comparisons against extra-Papuasian material indicate that the survey collections are merely a vigorous growth form. The lax venation noted previously (ibid) is actually within the range of variation for the species.

MIMOSACEAE

Archidendron hispidum (Mohlenbr.) Verdc.; coll. *11,210*. (**Fig. 1**). *Archidendron hispidum* was formerly recorded only from Northern and Milne Bay Provinces (Nielsen et al. 1984: 95; Nielsen 1992: 133). The Crater Mt. provenance places the species further west, and on the southern side of the Central Divide. The plant is apparently rare throughout its range.

There are two species in the series *Ptenopae* Nielsen to which *A. hispidum* is assigned (ibid). Although the congener *A. ptenopum* Verdc. has terminal inflorescences, it is now apparent that *A. hispidum* is strictly cauliflorous. The Crater Mt. specimen confirms that series *Ptenopae* is characterized by an inflorescence of pedunculate umbels. However, unlike *A. ptenopum*, the gynoecium in *A. hispidum* consists of a single ovary, so the pluricarpellate condition is not salient to the series.

An accessory description is provided for the previously unknown flowers of *A. hispidum*:

Inflorescence a panicle of umbels or (corymbs), cauligerous, pendulous, diffuse, to 15 3 12 cm, all axes filiform, nitid green, ± densely hirtellous; floral bractlets chartaceous, oblongish or widest above the middle, ca. 1.0 3 0.3 mm, falling early, aglandular, hairy; pedicels 5–11 mm long; rachide branches usually alternate, 20–50 3 0.2–0.4 mm, bracteate at the base, the rachis bracts scarious or not, acuminate, 0.7–2.0 mm long, persistent, adaxially glabrate, externally hirtellous; peduncle 5–52 3 0.4–0.5 mm. *Flowers* (measurements from spirit material) seen in bud only, up to 11 per cluster, bisexual, perianth pentamerous, subfleshy, green, hirtellous; calyx obconic, 1.0–1.5 mm long, margin subtruncate, erulose, or denticulate; corolla gamopetalous but connate only near the base, the lobes lanceolate or ovate, ca. 2.5 3 1.0–1.5 mm; androecium polyandrous (ca. 40–50), stamens glabrous, entirely white, column obsolete, ca. 0.5 mm long, filaments delicate, contorted,

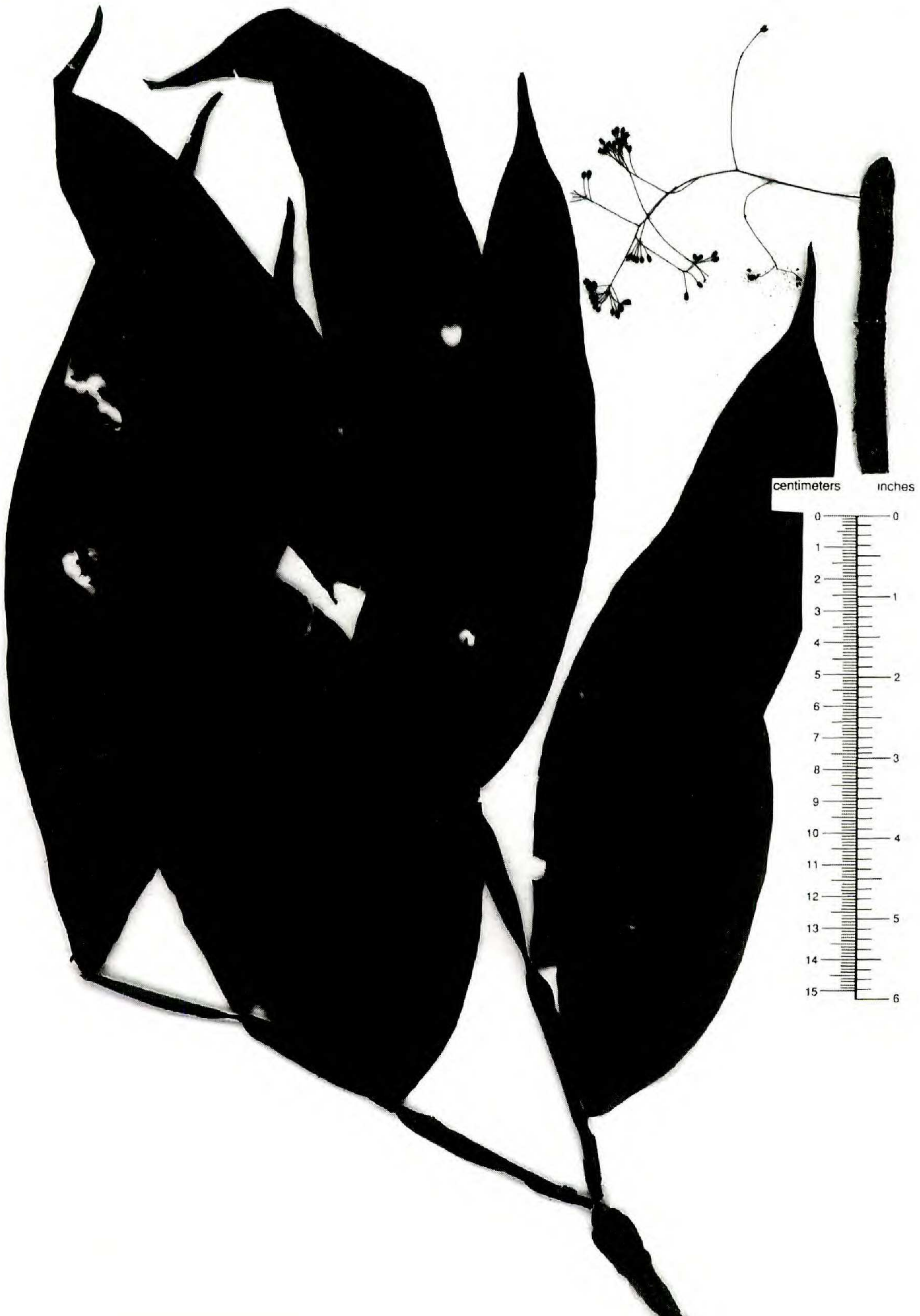

FIG. 1. *Archidendron hispidum* (Mohlenbr.) Verdc. Flowering habit. Scanned from *Takeuchi 11,210*.

anthers minute, globular, 2-locellate; gynoecium glabrous, sessile, ovary solitary, columnar, slightly reduced near the top, style cylindrical, equal to the ovary, stigma dilate, obconic to disciform.

MYRTACEAE

Syzygium hylochare (Diels) Merr. & Perry; coll. *11,847*. (**Fig. 2**). The survey voucher was previously cited as '*Syzygium* aff. *roseum* Merr. & Perry, possible sp. nov.' but has been rekeyed to the given binomial. Although the Crater Mt. specimen has leaves with very prominent, evenly-spaced, and more numerous lateral veins, it is otherwise referable to the new result. The stipitate base (4–5 mm long) on dried flowers and the comment of the stipes being very noticeable on immature fruits (Hartley & Perry 1973: 168) are deciding. These latter features are well-expressed on the survey number. *Syzygium hylochare* is also apparently characterized by the appearance of large pustules on the lamina and inflorescence after drying, in the manner of *S. malaccense* (L.) Merr. & Perry sens. lat. This identification aid can be advantageously appended to the couplet sequence for the species.

Syzygium hylochare is much closer to *S. roseum* Merr. & Perry than is apparent from the artificial key in Hartley and Perry (ibid). Specimens belonging to either facies should be compared against the congener, especially for collections from the southern districts.

PIPERACEAE

Piper arfakianum C. DC.; coll. *12,453*. The survey collection differs from the typical facies *inter alia* by the much sparser indument and the pendulous spikes with unusually filiform peduncles. The delicate peduncles are only 0.1–0.2 mm diam. (0.5–1.0 mm in other provenances) and the rachis is similarly narrowed to 0.5–0.6 mm diam. (normally 1.0–2.2 mm diam.). On the fully mature spike the individual fruits are elongate-ellipsoid rather than the more typical squat-obovoid shape, and laxly disposed so the rachis is occasionally visible between the berries. At 12 × 6.5 cm, the laminae are at the maximum end of the size range for the species. Although the Crater Mt. voucher was listed as '*Piper* sp. ?nov.' in the CMWMA checklist (Takeuchi 1999: 977) the collections at hand suggest that the survey number can be accommodated within the variable concept for *P. arfakianum* established in specimen annotations by Chew (cf. also Jebb 1987). While the character states for the Crater Mt. population appear distinct from the species sens. str., future collections should speculatively be able to unite the herbarium variation into a single continuum. If this does not eventuate, then the Crater Mt. plants will be deserving of future recognition as a separate subspecies or variety.

Piper is well-represented in the Crater Mt. Wildlife Management Area, with 17 species now documented for the locality.

ADDITIONS AND EMENDATIONS TO THE CRATER MT. PLANT CHECKLIST

The following taxa are listed as additions and emendations to the earlier compilation in Takeuchi (1999). Voucher source for occurrence record: LAE = staff collections from the Lae National Herbarium series; UPNG = institutional series from the University of Papua

FIG. 2. *Syzygium hylochare* (Diels) Merr. & Perry. Flowering habit. Scanned from *Takeuchi 11,847*.

New Guinea Herbarium; WT = W. Takeuchi. Other collectors indicated by name. Determinations by WT unless otherwise noted.

FERNS AND FERN ALLIES

ADIANTACEAE
Coniogramme macrophylla (Bl.) Hieron.; *WT 12,197*

DICOTS

ASCLEPIADACEAE (all dets. by P.I. Forster)
Hoya aff. *microphylla* Schltr.; *WT 12,449*
Hoya sussuela (Roxb.) Merr.; *WT 12,669*
Hoya sp.; *WT 12,752*
Marsdenia sp., probably nov.; *WT 12,469*

BURSERACEAE
Canarium acutifolium (DC.) Merr. var. *pioriverensis* Takeuchi; *WT 11,886A* (type), *11,886B*

ERICACEAE
Vaccinium acrobracteatum K. Schum.; *WT 12,451*, originally cited as 'Gaultherieae indet.'

EUPHORBIACEAE
Euphorbia plumerioides Teijsm. ex Hassk.; *WT 12,689*, the voucher previously cited (*WT 12,702*) is actually for *Codiaeum variegatum* (L.) Bl.

MELASTOMATACEAE
Medinilla forbesii Bak.; *J. Croft et al. LAE 61,178*, det. J. Regalado

MIMOSACEAE
Archidendron hispidum (Mohlenbr.) Verdc.; *WT 11,210*

MONIMIACEAE
Steganthera sp. nov. ined.; *WT 12,742* (type)

MYRTACEAE
Syzygium hylochare (Diels) Merr. & Perry; *WT 11,847*
Syzygium sp. nov. ined.; *WT 11,719* (type)

PIPERACEAE
Piper arfakianum C. DC.; *WT 12,453*

RUBIACEAE
Myrmecodia tuberosa Jack, entity '*muelleri*'; *UPNG 3,481*, cited in Huxley & Jebb (1993: 285).
Myrmecodia tuberosa Jack, entity '*versteegii*'; *UPNG 3,479*, (ibid: 287)

SAPINDACEAE
Rhysotoechia sp. nov. ined.; *WT 12,694* (type)

MONOCOTS

PANDANACEAE (all dets. by K.-L. Huynh)
Freycinetia acuta Huynh, sp. nov. in press; *WT 12,875* (type)
Freycinetia biroi Warb.; *WT 12,738*
Freycinetia craterensis Huynh, sp. nov. in press; *WT 11,955* (type)
Freycinetia lagenicarpa Warb.; *WT 11,761*
Freycinetia obtusiacuminata Huynh, sp. nov. in press; *WT 12,107* (type)

DISCUSSION

The flora of the Crater Mt. Wildlife Management Area (CMWMA) has been addressed, at least in part, by a succession of papers based on the 1997–1998 plant surveys. These

surveys were originally intended as part of a comprehensive assessment through a continuous elevational sequence, on a schedule eventually to culminate in the preparation of a plant identification guide. Because of the truncation of our itinerary in duration and scope, the major objectives are now out of reach. However the existing documentary base provides considerable opportunities for future investigators. As noted earlier, the lowland environment at Crater Mt. is still relatively unsurveyed and almost certainly presents rich prospective opportunities for discovery (Takeuchi 1999). Even though some work has already occurred in the low elevation zone, previous efforts have been brief and spatially restricted. The existing herbarium documentation is also highly skewed, with past collectors tending to focus on easy-to-obtain taxa such as understory herbs and shrubs. A conscious attempt to secure fertile gatherings of canopy/subcanopy phanerophytes and high epiphytes should prove rewarding. The previously reported discoveries of new plants from the ecotone contact with the Pio alluvial plain, are suggestive of the possibilities.

The Crater Mt. tract is positioned on the leading edge of the Australian craton, forming part of a southern geoprovince which is floristically depauperate in comparison to the speciose northern orogen of New Guinea (*inter alios* Pigram & Davies 1987; Welzen 1997). The contrasting species content on north-south orientations has been attributed to the orogenic etiology of northern New Guinea environments, and to increased speciation induced by the orogeny (Balgooy et al. 1996; Welzen 1997). At least part of the difference however, is an artifact of the uneven state of plant exploration in PNG, of which a salient element is the lesser number of collections from the southern districts. Since mountain-building processes appear to drive floristic endemism in New Guinea, the highest species density from its austral geoprovince should be expected on the latter's northernmost margin, where the plate has been forced upwards by tectonic collision with the island arc terranes. The novelties from Crater Mt. can be rationalized on this basis. Further exploration of the south descending side of the Dividing Ranges can be expected to produce similar results.

The CMWMA represents a previously unexplored expanse of wilderness forest. Recent discoveries from this tract are indicative of the necessity of surveying such areas as part of an overall program for developing veridical phytogeographic estimates of the New Guinea flora. The existing CMWMA checklist consists of a diverse mixture of allochthonous and autochthonous taxa, including many distributional records. While there are bases for anticipating that future findings will follow patterns suggested by geological correlation, new refinements are likely to arise from exhaustive work on the Papuan side. Additional surveys toward the lowland alluvial zone could eventually connect to the elevational anomalies discerned at Lakekamu (cf. Takeuchi & Kulang 1998; Takeuchi in press). At the latter site for example, *Palmeria gracilis* Perkins was found in lowland communities corresponding to Australian provenances, though the species is ordinarily strictly montane in Papuasia. A complete elevational series may be demonstrable at Crater Mt., where *P. gracilis* is already documented from its more characteristic montane stations.

Several generalizations can be offered from our ongoing inventory work in wilderness areas, many of them previously little-explored or unexplored. 1) Substantial numbers of undiscovered species are sequestered in lowland habitats, even in accessible places, having been unrecorded because of the poor documentation from low elevations (Takeuchi 2000). 2) Although montane areas are better documented than lowland ones, additional discoveries are more likely to result from working the south-descending ranges, on the margin of the Austro-craton, rather than the Mamose-descending side. To be sure, virtually any sort of serious effort will result in substantive discovery. Even at this late date in Papuasian botany, every major expedition comes back with new collections. 3) It is an imperative on inventories, for survey botanists to collect uncritically by taking everything encountered, in multiple numbers rather than being selective (Pipoly pers. comm.). Many of the most consequential findings from current investigations were of taxa whose significance was only revealed in the herbarium. This is especially true of novelties from speciose genera. If investigators are too choosy in what they gather, these sort of records will be missed. 4) In traditional PNG cultures, there is a characteristic emphasis on vegetative markers for plant identification, which not unexpectedly results in highly erratic nomenclatural systems. The significance and discriminatory value of vernacular names are considerably overrated. At Crater Mt., this is exemplified by the Pawaian 'way-e-be,' which was described as monotypic by village guides, but actually encompasses *Gymnacranthera*, *Horsfieldia*, and *Myristica*; in fact virtually the entire Myristicaceae. Numerous examples of comparable imprecision were documented during the CMWMA inventory. Especially when compilations are based on limited sampling, the local names will appear to be specific merely because of discontinuities in the polling. While it is often standard practice for investigators to report local names in revisionary work, these reports have little to acquit themselves unless they are cast in the context of a comprehensive census accompanied by comparative evaluation of the vouchers. Our experience is that such inquiry will reveal numerous examples of nomenclatural circumscription grossly incompatible with formal science. The quirkiness of local naming systems has also been shown in the ethnobotanical polling from the recent Josephstaal surveys (Takeuchi 2000).

The Integrated Conservation and Development (ICAD) strategy at Crater Mt. conjoins community-based conservation initiatives with low-impact socioeconomic development. Nearly all conservation programs in Papua New Guinea are now founded on this principle. As one of the largest of the ICAD experiments, the CMWMA also ranks among the floristically richest sites presently subsumed under this operational paradigm. Whether or not the ICAD philosophy can achieve programmatic success in places such as the CMWMA is still open to question (cf. Saulei & Ellis 1998). What the Crater surveys demonstrate is that the long-term viability of ICAD at Crater Mt. could have dramatic implications for a remarkable and precinctive flora. The nature of future scientific contributions to be forthcoming from this area is in many respects an imponderable, but the results achieved thus far clearly point to a considerable promise for further floristic discovery.

ACKNOWLEDGMENTS

The botanical surveys of Crater Mt. were supported by principal funding from the Liz Claiborne and Art Ortenberg Foundation, and by the John D. and Catherine T. MacArthur Foundation. Staff of the Research and Conservation Foundation of PNG (Robert Bino, John Ericho, Paul Hukahu, Paul Igag, and Arlyne Johnson) assisted with logistics and community liaison.

The Lae National Herbarium provided facilities for processing and identification of collections. Curators Emily Wood (A) and Debra Trock (BRIT) facilitated loans of critical specimens. Jin Komatsuzaki and Keiko Hanlon provided the Japanese translation.

I especially thank John Pipoly III for his constructive criticism and Barney Lipscomb for his generous assistance.

REFERENCES

Balgooy, M.M.J. van, P. Hovenkamp, and P. van Welzen. 1996. Phytogeography of the Pacific – floristic and historical distribution patterns in plants. In: A. Keast and S. Miller, eds. The origin and evolution of Pacific island biotas: New Guinea to Eastern Polynesia: patterns and processes. SPB Academic Press, Amsterdam, the Netherlands. Pp. 191–214.

Hartley, T.G. and L.M. Perry. 1973. A provisional key and enumeration of species of *Syzygium* (Myrtaceae) from Papuasia. J. Arnold Arbor. 54:160–227.

Huxley, C.R. and M.H.P. Jebb. 1993. The tuberous epiphytes of the Rubiaceae 5: A revision of *Myrmecodia*. Blumea 37:271–334.

Jebb, M.H.P. 1987. Key to *Piper* species in Papuasia. In: R.J. Johns. The flowering plants of Papuasia. Dicotyledons. Part 1: Magnoliidae. PNG University of Technology Forestry Department, Lae. Pp. 103–106.

Leenhouts, P.W. 1955a. The genus *Canarium* in the Pacific. B.P. Bishop Mus. Bull. 216:1–53.

_____. 1955b. Florae Malesianae Precursores XI. New taxa in *Canarium*. Blumea 8: 181–194.

_____. 1956. Burseraceae. Flora Malesiana ser. I, 5:209–296.

_____. 1959. Revision of the Burseraceae of the Malaysian area in a wider sense. Xa. *Canarium* Stickm. Blumea 9:275–647.

Nielsen, I.C. 1992. Mimosaceae (Leguminosae-Mimosoideae). Flora Malesiana ser. I, 11: 1–226.

_____, T. Baretta-Kuipers, and P. Guinet. 1984. The genus *Archidendron* (Leguminosae-Mimosoideae). Opera Bot. 76:5–120.

Pigram, C.J. and H.L. Davies. 1987. Terranes and the accretion history of the New Guinea orogen. J. Austr. Geol. Geoph. 10:193–211.

Saulei, S.M. and J.-A. Ellis (eds). 1998. The Motupore Conference: ICAD practitioners' views from the field. A report of the presentations of the second ICAD conference. Motupore Island (UPNG), Papua New Guinea 1–5 September, 1997. Dept. of Environment & Conservation, Papua New Guinea/United Nations Development Programme PNG/93/G31 Biodiversity Conservation & Resource Management.

STEENIS, C.G.G.J. VAN. 1972. Addenda, corrigenda et emendanda. *Canarium*. Flora Malesiana ser. I, 6:921–928.

TAKEUCHI, W. 1999. New plants from Crater Mt., Papua New Guinea, and an annotated checklist of the species. Sida 18:961–1006.

_____. 2000. A floristic and ethnobotanical account of the Josephstaal Forest Management Agreement Area, Papua New Guinea. Sida 19:1–64.

_____. In press. *Rhododendron loranthiflorum* (Ericaceae) from mainland New Guinea. A distributional record and new subspecies. Edinb. J. Bot. 57(3).

_____. In press. New and noteworthy plants from recent exploratory surveys in Papua New Guinea, 7. Edinb. J. Bot. 58(1).

_____ and J. KULANG. 1998. Vegetation Part 2: Botanical survey. In: A. Mack, ed. A biological assessment of the Lakekamu Basin, Papua New Guinea. Rapid Assessment Program Working Papers no. 9. Conservation International, Washington, D.C. Pp. 36–39, 105–130.

WELZEN, P.C. VAN. 1997. Increased speciation in New Guinea: tectonic causes? In: J. Dransfield, M.J.E. Coode, and D.A. Simpson, eds. Plant diversity in Malesia III. Proceedings of the Third International Flora Malesiana Symposium 1995. Royal Botanic Garden, Kew. Pp. 363–387.